1/15/85
BC800-1

NUEXCO

JANUARY 1985 NUMBER 197

MONTHLY REPORT

ON THE NUCLEAR FUEL MARKET

NUEXCO

HEADQUARTERS

Building 3, Suite 290
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO UI)

J. Robert Wolcott
Chairman

George White, Jr.
Senior Consultant-Marketing

Mathias M. Klingler
Chief Financial Officer

Richard K. Andersen, V.P.

Thomas A. Boyden, V.P.

R. Wesley Miller, V.P.

Christian C. Guitton

Kim Peyton McDonald

Donald W. Radcliffe

Judith L. Sellers

EUROPE

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

James E. Vaughan
Senior Vice President

Kathryn K. Bowen

W. Scott Hickman

James J. Lightner

NORTHEAST UNITED STATES

100 Prospect Street
Century Plaza South
Stamford, Connecticut 06901
Telephone: (203) 323-1999
Telecopy: (203) 325-1483
Telex: 4750124 (NUEXCO C)

Wayne D. Fowler
President

Robert J. Alexander

Earl E. Hoellen, Jr.

Teresa Elms Lindsay

SOUTHEAST UNITED STATES

Suite 905
Ten Piedmont Center
Atlanta, Georgia 30305
Telephone: (404) 262-7375
Telecopy: (404) 233-6210
Telex: 4611142 (NUEX ATL)

M. Jerry Reaves, V.P.

James H. Allen

Kathleen Rouhota

(See inside back cover for list of Representatives and Consultants)

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

January 1985 No. 197

R. WESLEY MILLER, *EDITOR* CLARK M. BEYER, *ASSOCIATE EDITOR*

PRICING
Natural Uranium and Conversion 1
Enriched Uranium and SWUs 1

CURRENT MARKET DATA
Nuexco Market Data Table 2
Prices Expressed in Selected Currencies 3
Recent Transactions 5
Supply and Demand Tables 6

ANALYSIS AND COMMENTARY
Optimum Tails Assay, Part 3 11

BASIC CONSIDERATIONS
US Nuclear Fuel Fabricators 15

RECENT DEVELOPMENTS
United States 20

HISTORICAL MARKET DATA
Graph of Exchange Value and Transaction Value 21
Historical Exchange Value, Transaction Value and Conversion Value ... 22

GOVERNMENT STATISTICS
Australia and Canada 23
South Africa and United States 24

INDEX TO 1984 REPORTS 25

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein.

NUEXCO

To Our Readers

Jerry Reaves

We are pleased to announce that Mr. **Jerry Reaves,** Vice President at our Southeast United States office, is now in charge of US and Far East brokerage operations. Jerry has assumed the position vacated by Wayne Fowler, who was named President effective December 1, 1984. Jerry will be responsible for the coordination of all brokerage activities in our US offices in addition to his current administrative duties.

* * *

Dick Andersen will be leaving Nuexco on January 11 to join Management Analysis Company in San Diego. We wish him good luck in his new pursuit.

© NUEXCO 1985

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

The **Exchange Value** as of December 31, 1984 is **$15.25** per pound U_3O_8, down $0.25 since last month. **Active supply** of natural uranium (U_3O_8 and UF_6) for spot or near-term delivery totals **3,640,000** pounds U_3O_8 or equivalent UF_6, down 1,600,000 pounds since last month. The corresponding figure for **active demand** is **1,250,000** pounds, down 60,000 pounds. The spot and near-term **supply-demand ratio** fell to **2.9:1.**

The *Current Market Data* section of this Report lists seven uranium sales transactions, involving a total of approximately 2,600,000 pounds equivalent U_3O_8. Six of the transactions reported this month involved deliveries before 1986, and five met the criteria for inclusion in the current Transaction Value calculation. One transaction is not current, in that it was concluded in mid-1984.

The **Transaction Value** as of December 31, 1984 is **$15.90** per pound U_3O_8, unchanged since last month. The current Transaction Value includes 16 transactions involving a total of 3.7 million pounds U_3O_8 or equivalent UF_6 and covers a period of 7 months.

The **Loan Use Charge Rate** as of December 31, 1984 is **6 percent** per annum, unchanged since last month in a dormant market.

* * *

The Exchange Value declined for the third month in a row as supply of natural uranium concentrates continued to exceed the highly discretionary demand. Increased competition between sellers for the few available opportunities forced the price of uranium down, as at least two transactions were concluded at or below the $15.50 level. Moreover, substantial quantities of natural uranium and UF_6 at the $15.50 price level failed to attract great interest. Of the few buyers in need of immediate delivery of material, most have failed to respond to offers in the $15.50 to $16.00 range.

The supply-demand ratio declined somewhat in December due to inventory clearances on the part of some sellers. Nevertheless, substantial quantities of material remain available, a condition which could apply continued downward pressure on spot and near-term delivery prices in the coming months.

Although five new transactions entered the Transaction Value calculation, the collective quantity was low enough to require the presence of the previous six months' transactions in the calculation in order to meet the required 2,000,000-pound minimum. Thus the recent transactions, despite the prices involved, have not yet begun to influence the Transaction Value significantly.

* * *

The **Conversion Value** is **$0.80** per pound U in UF_6, unchanged since last month. One secondary market conversion transaction is reported, involving approximately 275,000 pounds U in UF_6. Active supply of secondary market conversion services for delivery within three years fell slightly, to 1,000,000 pounds U in UF_6, as one supplier withdrew from the market. No active secondary market conversion demand is reported.

ENRICHED URANIUM AND SWUS

The Nuexco **SWU Values** as of December 31, 1984 are:

1. For **DOE origin,** a tails assay of 0.30 weight-percent U_{235}, and certifiable as excess:
   a. For FY85 delivery, $112 per SWU, down $3;
   b. For FY86 delivery, $15 discount from the USEC base price on delivery, unchanged;
2. For **other** SWUs (includes DOE origin SWUs not certifiable as excess and non-DOE origin SWUs):
   a. For delivery within approximately 15 months, $80 per SWU, down $5;
   b. For delivery in mid-to-late calendar year 1986, $90 per SWU, down $5.

Two secondary market SWU transactions are reported, involving approximately 90,000 SWUs. One transaction was of DOE origin, and one was of Eurodif origin.

* * *

The market for DOE origin SWUs certifiable as excess for FY85 delivery continues to disappear as most FY85 SWU buyers have made commitments, although small amounts of material should be available for a few more months. The demand for FY85 deliveries has largely been filled, and few buyers are actively soliciting offers. The entry of a new seller with significant quantities of FY85 SWUs forced the price down slightly in the absence of new demand. Many buyers are now focusing on the FY86 market, and with the presence of increasing demand, the activity is increasing. However, at this early date for FY86 SWUs certifiable as excess, there is still wide price disparity between sellers and buyers.

DOE customers exhibit little demand for SWUs that are either non-DOE origin or are not certifiable as excess. Most utilities not covered by the USEC have already purchased or are in negotiation, while those covered by the USEC are not allowed to fulfill SWU requirements from sources other than DOE until 1987. Thus, new deals for other SWUs are difficult to find at present. The demand in Europe for non-DOE SWUs has fallen considerably, bringing the prices down as some suppliers begin to compete for the few opportunities.

© NUEXCO 1985

NUEXCO

CURRENT MARKET DATA

December 31, 1984	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$15.25**/lb. U_3O_8	3,640	1,250
CONVERSION VALUE	**$0.80**/lb. U in UF_6	1,000	0
SWU VALUES			
DOE origin, certifiable as excess, 0.3 tails assay			
FY85 delivery	**$112**/SWU		
FY86 delivery	**$15** discount/SWU		
Other SWUs (non-DOE or non-certifiable)			
delivery within 15 months	**$80**/SWU		
delivery for mid-to-late calendar year 1986	**$90**/SWU		
LOAN USE CHARGE RATE	6%/annum	0	0

TRANSACTION VALUE	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
	15.90	3.7	16	7

[1]Supply and demand tables in the *Current Market Data* section of this Report detail the numbers for each category. Quantities of SWUs (Separative Work Units) are not referenced to a particular origin.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
3. The **SWU Values** represent Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
4. The **Loan Use Charge Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
5. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to offer, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not considered in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the DOE SWU Values, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminant variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

© NUEXCO 1985

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Dec. 31, 1984)	Last Month (Nov. 30, 1984)	12 Months Ago (Dec. 31, 1983)	This Month (Dec. 31, 1984)	Last Month (Nov. 30, 1984)	12 Months Ago (Dec. 31, 1983)
Australia (dollar)	18.37	17.99	24.50	47.77	46.77	63.69
Belgium (comm. franc)	960.33	959.16	1,226	2,497	2,494	3,186
Canada (dollar)	20.13	20.49	27.38	52.34	53.27	71.19
Finland (markka)	99.48	99.17	128.21	258.62	257.82	333.30
France (franc)	147.20	145.95	183.49	382.69	379.44	477.02
FRG (mark)	47.99	47.74	59.96	124.75	124.10	155.89
Italy (lira)	29,480	29,451	36,545	76,641	76,566	95,008
Japan (yen)	3,814	3,811	5,106	9,917	9,908	13,273
Netherlands (guilder)	54.08	53.65	67.46	140.59	139.48	175.39
South Africa (rand)	29.99	28.62	26.80	77.97	74.42	69.67
Spain (peseta)	2,638	2,663	3,466	6,857	6,923	9,011
Sweden (krona)	136.53	135.85	176.14	354.94	353.17	457.93
Switzerland (franc)	39.54	39.17	47.98	102.79	101.84	124.74
UK (pound)	13.10	12.88	15.19	34.05	33.50	39.50
US (dollar)	15.25	15.50	22.00	39.65	40.30	57.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Dec. 31, 1984)	Last Month (Nov. 30, 1984)	12 Months Ago (Dec. 31, 1983)	This Month (Dec. 31, 1984)	Last Month (Nov. 30, 1984)	12 Months Ago (Dec. 31, 1983)
Australia (dollar)	19.16	18.46	26.56	49.80	47.98	69.05
Belgium (comm. franc)	1,001	983.91	1,329	2,603	2,558	3,454
Canada (dollar)	20.99	21.02	29.69	54.57	54.65	77.18
Finland (markka)	103.72	101.73	138.99	269.64	264.47	361.33
France (franc)	153.47	149.72	198.92	399.00	389.23	517.14
FRG (mark)	50.03	48.97	65.00	130.07	127.31	169.00
Italy (lira)	30,737	30,211	39,618	79,908	78,542	102,998
Japan (yen)	3,977	3,910	5,535	10,339	10,164	14,390
Netherlands (guilder)	56.38	55.04	73.14	146.58	143.08	190.14
South Africa (rand)	31.27	29.36	29.05	81.29	76.34	75.52
Spain (peseta)	2,750	2,731	3,758	7,149	7,101	9,769
Sweden (krona)	142.35	139.35	190.95	370.07	362.28	496.43
Switzerland (franc)	41.22	40.18	52.02	107.17	104.46	135.23
UK (pound)	13.65	13.22	16.47	35.50	34.36	42.82
US (dollar)	15.90	15.90	23.85	41.34	41.34	62.00

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on December 28, 1984.

© NUEXCO 1985

NUEXCO

CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6			per kg. U as UF_6		
	This Month (Dec. 31, 1984)	Last Month (Nov. 30, 1984)	12 Months Ago (Dec. 31, 1983)	This Month (Dec. 31, 1984)	Last Month (Nov. 30, 1984)	12 Months Ago (Dec. 31, 1983)
Australia (dollar)	0.96	0.93	0.67	2.13	2.05	1.47
Belgium (comm. franc)	50.38	49.51	33.43	111.06	109.14	73.69
Canada (dollar)	1.06	1.06	0.75	2.33	2.33	1.65
Finland (markka)	5.22	5.12	3.50	11.50	11.28	7.71
France (franc)	7.72	7.53	5.00	17.02	16.61	11.03
FRG (mark)	2.52	2.46	1.64	5.55	5.43	3.61
Italy (lira)	1,546	1,520	996.68	3,409	3,351	2,197
Japan (yen)	200.10	196.71	139.24	441.14	433.66	306.98
Netherlands (guilder)	2.84	2.77	1.84	6.25	6.10	4.06
South Africa (rand)	1.57	1.48	0.73	3.47	3.26	1.61
Spain (peseta)	138.36	137.43	94.53	305.03	302.99	208.41
Sweden (krona)	7.16	7.01	4.80	15.79	15.46	10.59
Switzerland (franc)	2.07	2.02	1.31	4.57	4.46	2.89
UK (pound)	0.69	0.67	0.41	1.51	1.47	0.91
US (dollar)	0.80	0.80	0.60	1.76	1.76	1.32

SWU VALUES EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	DOE SWU FY85 (December 31, 1984)	Non-DOE SWU delivery within 15 months (December 31, 1984)	Non-DOE SWU calendar year 1986 (December 31, 1984)
Australia (dollar)	134.94	96.39	108.43
Belgium (comm. franc)	7,053	5,038	5,668
Canada (dollar)	147.85	105.61	118.81
Finland (markka)	730.59	521.85	587.08
France (franc)	1,081	772.20	868.73
FRG (mark)	352.42	251.73	283.20
Italy (lira)	216,509	154,649	173,980
Japan (yen)	28,014	20,010	22,511
Netherlands (guilder)	397.16	283.69	319.15
South Africa (rand)	220.26	157.33	176.99
Spain (peseta)	19,370	13,836	15,566
Sweden (krona)	1,003	716.20	805.73
Switzerland (franc)	290.38	207.42	233.34
UK (pound)	96.18	68.70	77.29
US (dollar)	112.00	80.00	90.00

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on December 28, 1984.

© NUEXCO 1985

CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current E.V.	Seller	Buyer	Remarks
3241	1985	less than 50	107	European Producer	Broker	
3240	1985	less than 50	103	US Producer	Broker	
3232	1985	less than 50	102	US Producer	US Producer	
3231	1984	601-1,000	R[2]	European Utility	European Utility	Not an arm's length transaction. Occurred in mid-1984.
3230	1985	50-100	106	Broker	US Utility	
3229	1984-1985	101-300	101	US Producer	US Utility	
3228	1991-1996	1,001-1,500	see remarks	Australian Producer	US Utility	Market related; dependent on floor price.

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

Secondary Market Conversion Services

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
3245	1985	101-300	63	US Producer	US Utility	Not an arm's length transaction.

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller Group	Buyer Group	SWU Origin	Remarks
3247	1985	less than 50	103	US Utility	US Utility	DOE	Sold from LEU inventory.
3248	1985-1986	50-100	78-88	European Entity	European Entity	Eurodif	

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[3]Price is not normalized to 0.30% tails assay.
[4]Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

© NUEXCO 1985

NUEXCO

CURRENT MARKET DATA

URANIUM SUPPLY
(December 31, 1984)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
1575	500	500 per year	
1860	400	1,500 per year	
2038	1,000	1,000 per year	UF_6
2288A	40	—	
2288B	295	—	UF_6
2389*	300	—	
2392	35	—	UF_6
2499	15	—	
2516	200	—	
2538*	55	—	
2565	400	—	
2569*	200	—	
2584*	200	—	
2134	—	220 per year	1985-87
2236*	—	200 per year	1985-89
2263	—	500 per year	1985-90
2625*	—	300 per year	1988-97
2654	—	1,050	1985-87
TOTAL:	3,640		
INACTIVE			
2191	125	—	UF_6
2275	150	—	
2335	275	—	
2336*	250	250 per year	1985-9[illegible]
2495	130	—	UF_6
2509	1,200	1,600	UF_6
2553	300	—	
0564	—	1,000 per year	1985-90
2271*	—	500 per year	1985-88
2297	—	200 per year	1986-89
2326	—	1,000 per year	1989-91
2368	—	250 per year	1987-90
2473*	—	500 per year	1985-90
2514	—	1,000 per year	
2574	—	500	UF_6
TOTAL:	2,430		

*New or revised since last month.

[1]Measured from the date of this Report.

[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2541, 2588, 2648.

© NUEXCO 1985

CURRENT MARKET DATA

URANIUM DEMAND
(December 31, 1984)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2419B	60	—	UF_6
2533	300	—	
2548	300	—	
2590	475	—	U_3O_8 or UF_6
2217	—	1,000 per year	1989-95
2442	—	4,000	1986-95
2507	—	600	1987-89
2540	—	400 per year	1989-94
TOTAL:	1,250		
INACTIVE			
2329	500	—	1985
2576	20	—	UF_6
2638*	325	325	UF_6
1999*	—	50 per year	1986-90
2244	—	350 per year	1987 on
2414	—	150 per year	1987-91
2457	—	350 per year	1988 on
2586*	—	300	1987
2643*	—	150 per year	1987 on
TOTAL:	845		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2539, 2555, 2568.

© NUEXCO 1985

NUEXCO

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(December 31, 1984)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale:			
ACTIVE			
2141	1,000	—	
TOTAL:	1,000		
INACTIVE			
2051	1,000	—	
2438*	500	250 per year	1986-87
2511	600	700	1986-90
TOTAL:	2,100		
Inquiries to Purchase:			
ACTIVE			
2644*	—	475	1987 on
TOTAL:	0		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: 2560.

LOAN SUPPLY AND DEMAND
(December 31, 1984)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
INACTIVE			
1938	2,000	—	UF_6
2128	700	—	
2139	2,000	—	
2469A	800	—	
2483	550	—	
TOTAL:	6,050		

*New or revised since last month.
[1]Measured from the date of this Report.

No inquiries to borrow this month.

© NUEXCO 1985

SWU SUPPLY
(December 31, 1984)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2100	150	100 per year	
2359*	130	—	
2583	50	—	
2624	100	—	
2631	150	—	
2632	25	—	
2285	—	300	
2378	—	120	1988
2510	—	50	
2513	—	25	1986
2517	—	150	1986-89
TOTAL:	605		
INACTIVE			
2164	25	—	
2589	50	—	
2531	—	150	1987
2571	—	55	1987
TOTAL:	75		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

© NUEXCO 1985

NUEXCO

CURRENT MARKET DATA

SWU DEMAND
(December 31, 1984)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2459*	30	—	
2480*	30	—	
2655	10	—	
2519	—	30 per year	1987 on
2578*	—	100	1986
2653	—	100	1986-90
2658*	—	5	1986
TOTAL:	70		
INACTIVE			
2443*	50	—	
2543	25	25	1986
2500	—	500	1987-90
2512	—	15 per year	1987 on
2585	—	100	1986
2595*	—	50	1986
TOTAL:	75		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2550.

© NUEXCO 1985

OPTIMUM TAILS ASSAY—PART 3

Introduction

Part 1 of this series (Report 195) developed the concept of the tails assay for which the cost of enriched uranium product is a minimum, assuming that the unit costs of feed material and SWU are both known constants. Part 2 (Report 196) discussed the variability of SWU prices with tails assay, and extended the concept of the minimum product cost to some instances of varying SWU prices. This third and final article in the series expands the analysis to include the dependence of inventory carrying costs on the tails assay, and discusses the true optimum tails assay for nuclear fuel management.

The Optimum Tails Assay

The objective by which utilities are measured is their ability to provide dependable service to their customers at the lowest possible cost. Given this goal, the optimum tails assay is the one which yields the lowest total fuel cost to the customers.

The fuel cost which is charged to customers is established by the nuclear fuel accounting system. There are nearly as many accounting systems as there are utilities, but (in the United States at least) utilities are regulated monopolies with the same central philosophy; all money prudently spent on the fuel is charged to the customers. However, customers are not billed as each fuel expense is incurred; they pay as the fuel is consumed. The fuel accounting system must keep track of all investments on a batch of fuel, as well as the interest (carrying) costs on these investments until they are repaid by the customers.

There are two different philosophies used in treating inventory carrying costs. Privately owned utilities are allowed to include in their electric rates a return on the investment in fuel which is included in their rate base*. If the fuel inventory is not included in the rate base, the accumulated carrying costs are added to the book cost of the fuel in inventory. From the customer's viewpoint, it matters little whether uranium inventory carrying charges are paid each year as a return on investment or accumulated and included in the cost of enriched product. For the following analyses, it is assumed that fuel is not in the rate base until it is loaded into the reactor, and the accumulated carrying charges are included in the unit costs of the fuel components.

* The fuel rate base is defined as the net investment in the fuel necessary to serve the customers. This has been interpreted by some regulatory agencies to mean only fuel loaded in the reactors, while others consider extensive natural uranium inventories to be necessary.

At the time a batch of fuel is inserted in the reactor, the total cost is divided by the energy the batch is expected to produce, giving a unit fuel cost to be charged to the customers. The total cost usually consists of five components: natural uranium feed, enrichment services, fabrication, disposal, and inventory carrying charges. The costs of fabrication and disposal components are independent of the enrichment tails assay, and will not be discussed further. The natural uranium and enrichment costs together constitute the cost of enriched uranium product. Carrying costs prior to irradiation are included in the component costs, and irradiation carrying charges are a multiplier of the cost of enriched product, and do not influence the tails assay selection. The optimum tails assay for the customer would appear to be the assay which minimizes the product cost. However, as shown below, this is usually not the case.

High Cost Uranium Inventory

Many utilities have some inventory of natural uranium feed, either the result of a deliberate decision to stockpile uranium or as a consequence of construction delays. Consider the following simplified example:

A utility has a 1,000-MWe reactor on an annual refueling cycle which requires 20 MTU of 3.5% enriched uranium per year. This utility has 1,500,000 lbs. U_3O_8 equivalent in inventory as UF_6. This inventory has a "book" value of \$150/KgU (\$55/lb. U_3O_8, \$3/lb. U conversion), which is the original purchase price plus the cost of carrying the inventory to the current date. The utility has no existing contracts for natural uranium, and plans to purchase new material to meet requirements after its inventory has been exhausted. The price for new natural uranium is \$55/KgU (\$20/lb. U_3O_8, \$1/lb. U conversion) plus escalation. There is a requirements enrichment contract for \$135/SWU plus escalation, which is not a function of tails assay. The utility has a cost of capital and discount rate of 10 percent, and assumes an escalation rate of 5 percent. What is the optimum tails assay for this utility—the tails assay which will result in the lowest cost of fuel for its customers?

First Year Costs

The cost of the enriched product assigned to each fuel batch, and thus passed on to the customer, is determined by the following equation (see Report 195):

$$\text{Product Cost} = \text{Feed Factor} \times \text{Unit Feed Cost} + \text{SWU Factor} \times \text{Unit SWU Cost}$$

© NUEXCO 1985

ANALYSIS & COMMENTARY

The Feed and SWU factors are a function of tails assay and product enrichment. Once the tails assay has been selected, the assigned cost of enriched uranium for the first batch can be calculated using the feed book cost of $150/KgU and the first year SWU cost of $135. The cost of the enriched uranium product (in $/KgU) for the first year is shown as a function of the enrichment tails assay in Figure 1.

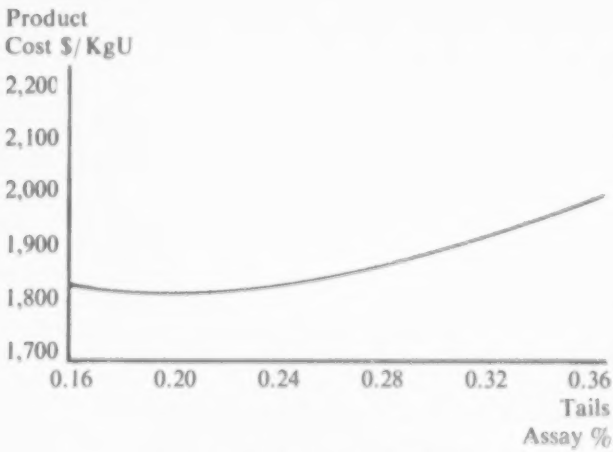


Figure 1. First Year Fuel Cost

The utility has a relatively high feed cost, so the cost of fuel assigned to its first reload batch is reduced by using a low tails assay (less feed and more SWU). The optimum tails assay for the first year's fuel cost can be derived directly from the relationships developed in Part 1 for the minimum cost of enriched product, given constant SWU and feed costs. The first year feed/SWU cost ratio is 1.1, and the tails assay for minimum product cost is about 0.22 w/o, which is the same as the tails assay for the lowest fuel cost in Figure 1.

Costs for Future Years

While a tails assay of 0.22 w/o is indeed the optimum for the first batch, it does not yield the lowest cost for fuel in future years. Figure 2 shows the average cost of a kilogram of enriched uranium for *six* batches of fuel.

The long term fuel cost (which includes the first year) has the opposite dependence on tails assay, and indicates that a tails assay of at least 0.36 percent would provide the lowest fuel costs to the customers. What has happened to create this apparent anomaly?

The answer lies in the fuel cost accounting system and the cost of carrying the natural uranium in inventory.

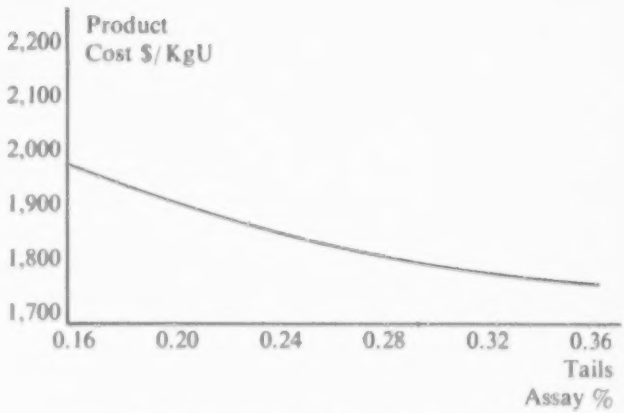


Figure 2. Six Year Average Fuel Cost.

Figure 3 shows the natural uranium inventory in terms of years of forward supply at the end of each year for several different tails assay selections. The original inventory will be consumed at a rate of 350,000 lbs. U_3O_8 per year at a tails assay of 0.22 w/o, while 467,000 lbs. will be used each year at a tails assay of 0.36 w/o.

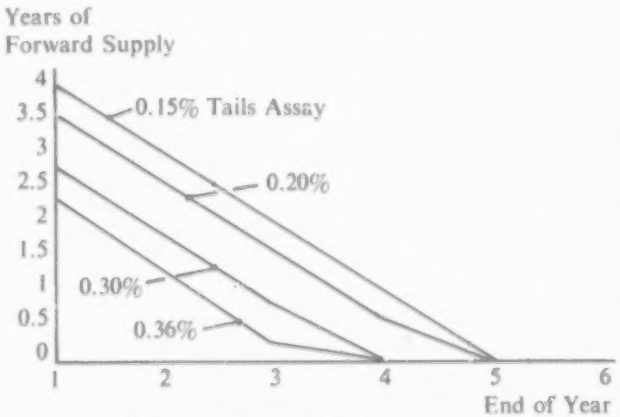


Figure 3. Natural Uranium Inventory.

There is a cost of carrying inventory material of 10 percent per year, which is paid by future customers, as the book cost of the feed material is increased by the accumulated carrying charges. In real terms, this cost is reduced by the appreciation of inventory value, i.e., if the cost of replacement material increases. In this example, the cost of replacement feed is lower than the inventory cost, so the appreciation is negative and real carrying costs are very high.

© NUEXCO 1985

Figure 4 provides further insight into the example, showing the average annual assigned cost per kilogram for years one through six. In this figure, future costs are discounted by the customer's time value of money (assumed to be 10 percent per year).

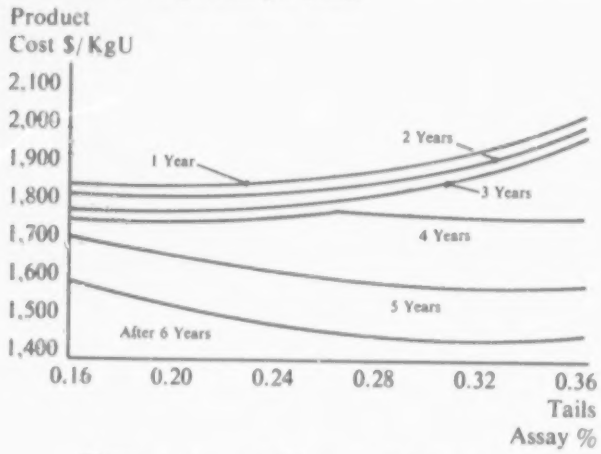


Figure 4. Average Discounted Fuel Cost.

The results show that optimum tails assay for the *average* cost of fuel assigned is about 0.22 w/o for the first 3 years, but jumps to about 0.32 w/o for planning horizons of over 5 years. The reason for this turnabout is that the original high-cost inventory is finally exhausted in year 4. At the higher tails assays, the cost savings for using market value feed in the later years overwhelm the higher assigned costs in the earlier years.

Determination of Optimum Tails Assay

If minimizing the cost of fuel assigned gives misleading results, what performance measurement should be used to calculate the optimum tails assay? In addition to the impact on the current batch, we must also consider the changes in costs for future batches. In the example, if lower tails assays were used to reduce current fuel costs, the feed material *not* used (costing $150/KgU plus accumulated carrying charges) had to be assigned to some future batch. If higher tails assays were used, the future batch could have used new material purchased at less than $75/KgU.

Discounting the future savings by the cost of money, the long-term optimum tails assay for utility customers can be approximated by the tails assay for minimum product cost (see Appendix), if the *discounted future price of uranium feed is used, rather than the book value.* In the example, assuming that additional feed is required in the fourth year, the market price of the next feed to be purchased, discounted to the current year, is $45.20/KgU. With $135 SWU, the optimum tails assay is approximately 0.35 w/o, which coincides well with the results of Figure 4. It should be noted, however, that both the example and the above approximation assume that the same tails assay is used each year.

Another commonly used method of determining the optimum tails assay is to minimize future discounted cash flow. The discounted cash flow at the end of one through six years is shown as a function of tails assay in Figure 5.

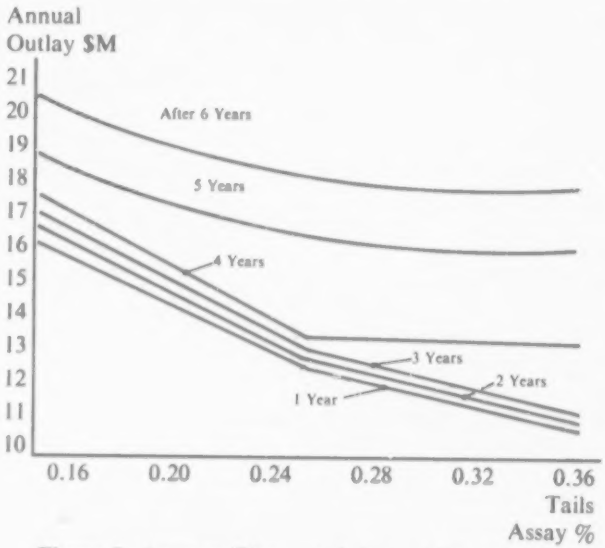


Figure 5. Average Discounted Annual Expenditure.

Comparing Figure 5 to Figure 4, the tails assay for minimum discounted cash flow is about the same as the tails assay for minimum fuel cost for planning periods beyond four years. However, tails assay for minimum cash flow in the first three years is unrealistically high, as there are no requirements for additional feed purchases in these years. The discounted cash flows for years 4 through 6 are more valid measurements, as they factor in replacement feed costs.

Other Fuel Management Objectives

While all utilities are concerned with reducing the costs of fuel assigned to their customers, many also consider the net investment in fuel (or credit requirements) to be an important measurement. If fuel in inventory is not includ-

© NUEXCO 1985

ed in the rate base, cash is only generated as the fuel is consumed to produced electricity. A batch of fuel is typically in the reactor for about four years, so the utility will receive income from a batch at the rate of about 25 percent of its assigned cost each year. Actually, income is somewhat higher for the first year, and lower for the last, due to uneven burnup rates. In any case, the utility must use its own capital or lines of credit to finance the fuel investment. This can be a critical problem for utilities that are in financial distress.

For the utility used in the example, a higher tails assay reduces net investment in two ways. First, in the earlier years, there are no cash expenditures for feed, and the higher tails assay reduces the SWU requirements, yielding lower cash outlays. The higher tails assay provides a second benefit, as the cost of fuel assigned to batches will be higher in the earlier years (see Figure 4), resulting in increased fuel costs for customers, and thus higher income. There should be no trouble in convincing regulatory agencies of the benefits of higher tails, as the net cost of fuel to the customer is reduced in the longer term.

Summary

In this series of articles, we have tended to focus on individual pieces of the tails assay puzzle, in order to illustrate the effect of each variable. There have also been a number of simplifying assumptions (such as the use of a constant tails assay, rather than one which varies from year to year). In today's market, all of the variables interact, and the true optimum tails assay is a complex function of the inventory, regulatory, financial and contractual situation for each utility.

In many of the cases, the assumptions of constant feed and SWU costs give the wrong trends of cost versus tails assay. It is clear that traditional methods of tails assay optimization are no longer adequate, and sophisticated analyses are necessary to enable fuel managers to realize their true objectives. Fortunately, the development of powerful personal computers and fuel management software has made it possible to perform those analyses relatively quickly and efficiently.

APPENDIX

Optimum Tails Assay with Uranium Inventory

The total cost impact of a batch of fuel is equal to its current assigned cost, plus its effect on the cost of future batches. The current assigned batch cost is:

$$\text{Product Cost} = B \times \text{Feed Factor} + \text{SWU Cost} \times \text{SWU Factor},$$

where B is the book value of natural uranium feed.

In some future year N, the utility will have to purchase additional feed material. In that future year, the utility will use some amount (I) of feed material from inventory, and some amount (M) from the future purchase. If the tails assay in the current year is increased to some new value so that one additional kilogram of inventory material is used, this will reduce the quantity I by 1 KgU and increase M by the same amount. The fuel cost in the future year will be reduced by the difference between the cost of the inventory material in year N (the current book cost B, plus N years of compounded interest (i)) and the cost of the future purchase (P):

$$\text{Future Cost Difference} = P - B \times (1 + i)^N$$

Discounting the future cost difference by the same interest rate yields:

$$\text{Discounted Future Cost Difference} = P/(1 + i)^N - B.$$

Returning to the cost of the current assigned batch, with the increased tails assay, the difference between the new and the old cost is:

$$\text{Product Cost}' - \text{Product Cost} = B + \text{SWU Cost} \times (\text{SWU Factor}' - \text{SWU Factor})$$

Combining the current product cost with the discounted future cost difference gives:

$$\text{Total Cost}' - \text{Total Cost} = P/(1 + i)^N + \text{SWU Cost} \times (\text{SWU Factor}' - \text{SWU Factor})$$

By inspection, the equation for the total cost differential is similar to the equation for the product cost differential, except that the discounted future price for feed is used instead of the current feed book value. Thus, the tails assay for the minimum total cost can be found by using the discounted future price in the equations for the minimum product cost.

© NUEXCO 1985

US NUCLEAR FUEL FABRICATORS

Introduction

Five companies in the USA fabricate nuclear fuel for light-water reactors (LWRs). General Electric Corporation, Westinghouse Electric Corporation, Exxon Nuclear Company, and Combustion Engineering, Inc. produce fuel assemblies by converting enriched UF_6 to UO_2 powder, forming fuel pellets, and loading the pellets into fuel rods (Table 1). The rods are arranged into bundles and shipped to reactors throughout the world. The fifth US company, Babcock and Wilcox, performs rod assembly using fuel pellets supplied by G.E. The fabricators provide engineering support services such as fuel management and in-core monitoring, and are continuing research and development of new fuel technology that will facilitate fuel burnup efficiency and enhance power distribution control. The fabricators are enacting new design and operational strategies in an attempt to reduce fuel cycle costs.

The Fabrication Process

Although techniques used by each fuel fabricator vary, the basic process is standard throughout the industry. All fabrication processes for fuel used in LWRs begin with the conversion of enriched UF_6 to uranium dioxide, UO_2. In the most commonly used process, the gaseous UF_6 reacts with ammonia and water to form ammonium diuranate. The resulting precipitate is calcined (roasted) to form UO_3, which is reduced with hydrogen to produce the UO_2 powder. The powder is sampled and analyzed for fluoride and moisture content, and then it is pressed into pellets. The pellets are sintered to increase the fuel density and remove moisture, a process which permits the loading of proportionately more fuel per tube. Moreover, sintering reduces the densification of fuel pellets while in the reactor, a condition which can cause fuel failures. The pellets are then ground to uniform size and are ready to be loaded into fuel rods.

Most fuel rod tubes are made of Zircaloy, a zirconium alloy which is highly corrosion resistant and absorbs few neutrons. Localized fuel failures often are caused by rapid changes in core power levels during normal operation. Such power changes can cause local stress loading and chemical reactions between pellets and cladding, called pellet-clad interaction (PCI). When differential thermal expansion occurs between the pellets and cladding as reactor power increases, the cladding can crack. All of the US fabricators have launched efforts to counter the effects of local stress loading and PCI.

The pellets are loaded into the fuel rods to precise specifications to allow for pellet expansion and efficient burnup. The rods are filled with an inert gas such as helium to provide thermal conductivity and avoid chemical reactions with released fission gases; a plenum spring is inserted, and end caps are welded on. The plenum spring exerts a downward pressure on the stacked pellets, keeping them in place during the handling of the bundle (Figure 6). A thorough inspection sequence follows in which

Table 1

US NUCLEAR FUEL FABRICATORS

Company	Plant location	Fuel type	Production capacity (MTU in UO_2/year)
Babcock & Wilcox	Lynchburg, Virginia	PWR	400
Combustion Engineering	Hematite, Missouri[1] Windsor, Connecticut[2]	PWR	275
Exxon	Richland, Washington	PWR, BWR	700
General Electric	Wilmington, North Carolina	BWR	2,000
Westinghouse	Columbia, South Carolina	PWR, BWR	1,000

[1] Provides conversion only.
[2] Provides fabrication only.

© NUEXCO 1985

NUEXCO

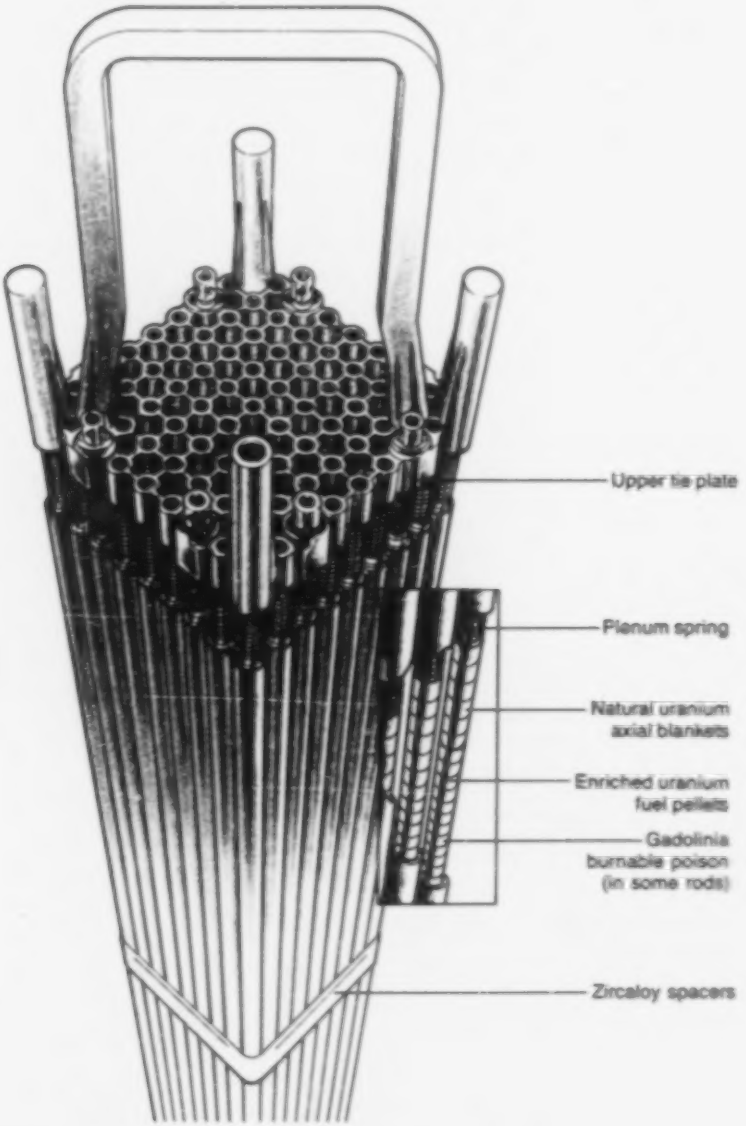


Figure 6. Exxon 9×9 BWR fuel assembly.

© NUEXCO 1985

the rods are tested for weld integrity, pressurization, uniformity, and enrichment. Although PWR assemblies generally use pellets with uniform enrichment levels, several different enrichment levels are used in BWR fuel assemblies to reduce local power peaking. An initial core for a BWR has an average enrichment ranging from 1.6 weight-percent (w/o) U_{235} to 2.2 w/o U_{235} depending on initial cycle requirements. Each assembly contains approximately four different enrichments; low-enriched rods are used in the corner rods and the rods nearer the water gaps, while higher enriched rods are placed toward the center of the fuel bundle (Figure 7). Reload fuel usually contains a higher average enrichment level, in the range of 2.4 w/o to 3.0 w/o. Selected rods contain pellets that have been blended with a burnable poison (gadolinium nitrate), a neutron absorber that helps moderate the reaction, yet also is consumed along with the U_{235} so that it does not inhibit the reactivity at the end of each operating cycle.

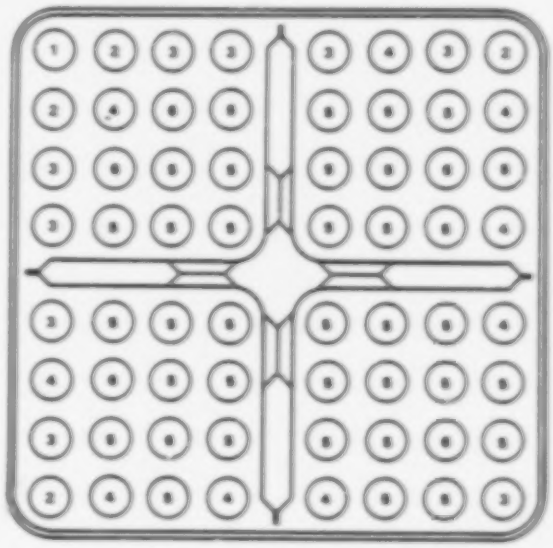
The Commercial Fabricators

Westinghouse Nuclear Fuel Division fabricates fuel assemblies at its plant in Columbia, South Carolina. The plant began operation in 1969, with a capacity of 200 metric tons uranium (MTU) produced each year, and has manufactured and shipped over 15,000 nuclear fuel assemblies to its customers worldwide. Current annual fabrication capacity of the Columbia plant is over 1,000 MTU in UO_2. The Nuclear Fuel Division also operates the Westinghouse Specialty Metals Plant in Blairsville, Pennsylvania. The Specialty Metals Plant manufactures Zircaloy fuel rod cladding for use at the Columbia plant as well as for customers worldwide.

In recent years, Westinghouse has developed programs designed to improve the quality of fuel products, including the improvement of fuel rod and plug welding techniques, the reduction of fuel hydrogen levels, and better rod handling techniques. The Westinghouse Optimized Fuel Assembly (OFA) design, introduced into commercial operation in 1983, incorporates several features intended to improve fuel economy, such as Zircaloy grids for rod spacing in the bundle, and a smaller fuel rod diameter to accommodate more fuel rods per bundle. Eight PWRs are operating with this design.

The most recent development is the VANTAGE 5 design. Consisting of several features including axial blankets (areas of natural uranium pellets at the top and bottom of each fuel rod), removable top and bottom nozzles, and integral fuel burnable absorbers, VANTAGE 5 features can be utilized individually or as a whole in PWR assemblies. The system is designed to improve fuel performance; the axial blankets are said to improve uranium utilization by 2.5 percent. Mechanical testing of the design has been completed, and all of the features have been delivered and loaded at South Carolina Electric & Gas Company's Summer Unit 1.

A new production facility, known as the Manufacturing Automated Project (MAP) is under way at the Columbia plant. MAP is intended to integrate automated systems for the manufacture of nuclear fuel rods. The process covers conversion of UF_6 to UO_2, pellet manufacture, and completion of the fuel rods. Westinghouse expects that the use of robotics and process automation techniques will result in greater efficiency and a significant reduction in manufacturing cycle time.



Rod Type	No. of Rods	Enrichment U_{235}
1	1	1.70
2	4	2.10
3	9	2.50
4	9	2.80
5	34	3.10
6	7	2.95

Lattice Enrichment: 2.873
Bundle Enrichment: 2.70

Figure 7. Uranium enrichment distribution for BWR fuel assembly.

© NUEXCO 1985

NUEXCO

BASIC CONSIDERATIONS

Westinghouse also has been competing for BWR reload fuel orders and, under a licensing agreement with Asea-Atom of Sweden, has developed QUAD+ reload fuel in the hopes of supplanting some of General Electric's dominant share of the BWR fuel market. The QUAD+ design provides a water channel in the middle of the assembly which divides the fuel rods into four quadrants. Westinghouse has sold four QUAD+ demonstration assemblies to Tennessee Valley Authority's Brown's Ferry Unit 2 for delivery in early 1985.

General Electric began fabricating fuel at its Wilmington, North Carolina plant in 1968. The plant manufactures BWR fuel bundles in an 8×8 rod array, and has manufactured approximately 35,000 fuel bundles for BWR plants around the world. G.E. also has implemented manufacturing or technology exchange agreements in nine countries, including Kraftwerk Union in the Federal Republic of Germany and Asea-Atom in Sweden.

G.E. is placing increasing reliance on automation. Computer-controlled and monitored manufacture of Zircaloy tubing for fuel rods and automated inspection of cladding for dimensional characteristics are designed to improve product integrity. For the production of nuclear fuel, laser inspection systems and a mechanical handling system apply automation to the pelletizing process. The machines process the inspection data and decide to accept or reject components. Fabrication personnel study the rejected pellets to monitor the grinding and sintering processes.

Each G.E. BWR fuel bundle consists of 62 fuel rods and two water rods. The end plug of each fuel rod is stamped with a serial number so that the contained uranium can be traced from a cylinder of UF_6 to the reactor. Another tracking system, the Manufacturing and Information Control System (MICS), uses two large computers to monitor the flow of over a quarter million containers of uranium annually. Since the varying enrichment levels and location of the uranium that passes through the automated equipment must be monitored at all times, MICS was designed to keep track of materials through the entire manufacturing process to prevent the mixing of enrichments.

The final quality control step in the manufacture of gadolinia fuel rods at Wilmington is performed by the Magnetic and Passive Scanner (MAPS). MAPS, a superconducting magnetometer, measures the uranium and gadolinium content of every pellet in every finished fuel rod. Superconducting coils immersed in liquid helium at a temperature of four degrees Kelvin (4 degrees above absolute zero) scan the rods and the system stores the data, including pellet density, cladding wall thickness, and gaps between pellets.

G.E.'s recent workforce cut at Wilmington did not affect the fuel fabrication division, although 200 other jobs were lost, mostly in the reactor parts division. G.E. is testing its newest fuel design, GE9B, and plans to begin marketing it in a few years. The current design, GE8B, utilizes the barrier fuel concept. A thin protective layer of soft zirconium metal is bonded to the inner surface of the cladding. G.E. expects it to provide resistance against pellet-clad interaction (PCI), the mechanical and chemical reaction between fuel pellets and cladding, a chief cause of localized fuel failures.

Exxon Nuclear Company, a wholly-owned affiliate of the Exxon Corporation, fabricates fuel for BWRs as well as PWRs. It also provides engineering services such as in-core fuel management, in-core monitoring, and irradiated fuel performance evaluation. The fabrication facility, located in Richland, Washington, has been expanded several times since 1969 and currently has a capacity of 700 MTU per year. Exxon has fabricated and delivered over 5,000 fuel assemblies to 39 nuclear plants throughout the world. Approximately half are BWRs and half are PWRs.

Like the Westinghouse VANTAGE 5, Exxon fuel assemblies utilize dismountable upper tie plates for both BWRs and PWRs. As a result, it was possible to repair and reinsert 12 damaged rods in Belgium's Tihange Unit 1 PWR assemblies. Gadolinia burnable poison, originally developed for BWRs, has been successfully extended to PWRs, resulting in improved fuel efficiency. In 1982, Exxon completed a study which indicated some advantages of a 9×9 fuel rod array for BWR assemblies; Exxon concluded that the 9×9 design has substantial fuel cycle benefits as well as increased resistance to PCI. The company also is involved in several joint venture research programs aimed at further improvement in fuel performance and fuel cycle cost.

Exxon offers a range of fuel-related engineering services designed to augment its delivery of nuclear fuel. These include fuel management and licensing, in-core monitoring, poolside irradiation fuel examinations, and irradiated fuel reconstitution. In addition, Exxon introduced a core monitoring software system, in use on several BWRs, as a method of correlating power distribution data and assisting with operational problems. The company is developing a similar model for PWRs. Exxon will demonstrate its advanced PWR fuel, utilizing annular pellets and zirconium cladding, in the spring of 1985 at

© NUEXCO 1985

Rochester Gas and Electric's Ginna unit.

Combustion Engineering (C-E) has produced PWR fuel assemblies for eleven reactors in the USA. Two separate facilities are utilized. UF_6 is converted to UO_2 powder at the Hematite, Missouri plant, and the pellet fabrication and fuel rod assembly takes place in Windsor, Connecticut. The latter plant has a capacity of 275 MTU per year. Assemblies are manufactured in 14×14, 15×15, and 16×16 arrays, and the manufacturing process uses digitally-controlled equipment extensively.

Combustion Engineering, as a vendor of nuclear steam supply systems, is capable of directly providing all engineering support services. Reload engineering is closely tied to C-E's other activities as a reactor supplier, so that the technological exchange of information is consistent throughout C-E's programs. In addition, a technology exchange with Kraftwerk Union GmbH (KWU) of the Federal Republic of Germany involves a cooperation in research and testing.

Commercial utilization of many fuel performance innovations has been in effect for several years. C-E began using all Zircaloy grids in 1972, as well as low residual burnable poison absorbers with Zircaloy cladding. In 1974, C-E increased the plenum volume, or space inside the fuel rods, to provide greater high burnup capability. C-E has experience in handling reconstitutable fuel assemblies, having shipped reconstitutable fuel since 1974.

C-E is scheduled to deliver fuel to Yankee Atomic Electric Company's Rowe unit, a Westinghouse PWR, in the summer of 1985. It will represent the first C-E fuel assembly loaded into a reactor built by another vendor.

Babcock & Wilcox's Commercial Nuclear Fuel Plant (CNFP) has been involved in the manufacture of fuel assemblies for commercial nuclear power stations since 1963. The CNFP's scope of activities includes the fabrication of fuel assemblies, and the manufacture of spacer grids, burnable poison components, control components, in-core detectors, and associated parts. B&W provides complete mechanical design, quality assurance, fuel management, and reload licensing.

B&W provides PWR fabrication assembly services at its facility in Lynchburg, Virginia, but is no longer involved directly in the conversion or pelletizing processes for LWRs. B&W uses pellets manufactured by G.E. for its assemblies. In September 1982, B&W announced its decision to subcontract UO_2 powder and fuel production to G.E.'s Wilmington plant. At that time, B&W had been planning to shut down its own UO_2 powder production facility in Apollo, Pennsylvania because of reduced demand. The Apollo plant was shut down in the summer of 1983, and the first G.E. pellets were supplied in November 1983.

B&W employs several unique design concepts when fabricating LWR fuel assemblies. Two plenum springs, one on each end, are inserted in each fuel rod tube to prevent jamming or dislodging of pellets in transit. Floating Zircaloy spacer grids allow the independent expansion of each fuel rod; the rods are not welded to the spacer grid. B&W also introduced "keyed" spacer grids whereby a series of keys disengage springs in the grid, allowing the rapid removal of fuel rods during the fabrication and inspection processes.

When Northeast Utilities' Connecticut Yankee reactor recently broke the world record for consecutive days of continuous operation by a light-water reactor, the 575-MWe Westinghouse PWR generated more than 69 billion kilowatt-hours of electricity, about 60 percent of which was generated with B&W-manufactured fuel. Another reactor using B&W fuel assemblies, Duke Power Company's Oconee Unit 3, had a 1983 capacity factor of 94 percent, the highest for a reactor in the USA.

B&W fuel technology also has been implemented to some degree overseas. Nuclear Fuel Industries, Ltd. (NFI) of Japan designs and fabricates some PWR fuel assemblies under a licensing agreement with B&W. Signed in 1976, the long-term agreement transferred B&W's PWR fuel technology to NFI. NFI now supplies about 40 percent of the Japanese PWR reload fuel market.

CORRECTION

In the *FOCUS* article on Sweden in Report 196 (December 1984), a line was dropped out inadvertently in the typesetting process. The reference to the USEC conversion status of Sydkraft and SSPB on page 24 should have read:

Both Sydkraft and SSPB have contracts with DOE for enrichment services; while Sydkraft converted its Requirements *contract to the USEC, SSPB has not converted its two 3.5-year Requirements* contracts and five AFCs (Adjustable, Fixed-Commitment contracts) to the USEC.

© NUEXCO 1985

NUEXCO

RECENT DEVELOPMENTS

UNITED STATES

Introduction

In early December, three US uranium producers filed suit against the US Department of Energy (DOE) and various DOE officials in the US District Court in Colorado. Western Nuclear, Inc., Energy Fuels Nuclear, Inc., and Uranium Resources, Inc., with the support of other producers, filed a civil action asking the court to declare the Utility Services' Enrichment Contract (USEC) null and void. The wide-ranging complaint also seeks:

1. To have DOE's definition of viability of the US uranium industry invalidated and to require DOE to restrict the enrichment of non-US origin uranium for domestic end use until such viability is assured;
2. To prohibit DOE from utilizing a fixed tails assay and restricting uranium demand through the VTAO surcharge in the USEC;
3. To prohibit DOE from selling uranium, either directly or indirectly (via such mechanisms as the split tails and pre-produced inventory policies) in competition with the domestic uranium industry.

Commentary

The lawsuit is the culmination of efforts, begun in 1980, by the US uranium industry to strengthen the domestic uranium market. Prior to the lawsuit, the industry focused its attention on legislative attempts to limit US utility use of non-US origin uranium. The first attempt occurred in the fall of 1980 when Senator Domenici (R, New Mexico) attempted to attach an amendment to DOE's 1981 appropriations bill. The amendment was deleted from the bill when requisite support failed to materialize (see Report 146, October 1980).

Senator Domenici tried again in March 1982 when he proposed the requirement that 80 percent of the uranium used by US reactors must be of US origin. This attempt also failed, and the pro-embargo forces achieved neither their original 20-percent limit nor a compromise 37.5-percent limit on imports of non-US origin uranium. However, in January 1983 they did succeed in passing legislation that established a framework of studies and required reports that could be utilized to implement import restrictions in the future (Report 174, February 1983).

The results of this legislation have disappointed US producers. The President's March 31, 1984 Report to the Congress on the US uranium industry was not seen as supportive, and the Reagan administration has shown a marked reluctance to support embargo initiatives of the type sought by the US industry.

In this context, the USEC became the final affront to industry expectations. The USEC is a requirements-type contract which reduces and defers uranium demand. Further, a surcharge was added making tails assays above 0.20 w/o U_{235} less attractive and, as the result of individual negotiation, a number of utilities gained the right to utilize existing inventories of enriched product, further reducing and delaying the need for new supplies of material.

Despite a series of meetings with DOE and the threat of a lawsuit since early 1984, the US producer group was unable to obtain any tangible relief from DOE. DOE spent much of 1984 developing enrichment policies that would allow retention of its market share which was under challenge from foreign suppliers and the secondary market.

If the courts voided the laboriously constructed USEC, DOE's credibility would be impaired severely, particularly among foreign customers who have little understanding of the US judicial system. Urenco and Eurodif would achieve substantial gains at DOE's expense.

In a report released on December 27, 1984, the General Accounting Office (GAO), the investigative body of Congress, appeared to lend considerable support to the producers' contentions about the USEC. The GAO report was highly critical of DOE, adding that DOE's "actions with regard to the new Utility Services Contract were not in compliance with applicable statutory principles." GAO further noted that the $135 per SWU price "would violate the Atomic Energy Act's provision requiring cost recovery." The greatest potential impact of the GAO report could arise from a Congressional reaction that forces DOE compliance with the law as interpreted in that report.

Many obstacles confront a negotiated resolution to the situation. Dropping the VTAO surcharge or the fixed tails policy would result in a revenue loss that would jeopardize DOE's assertion of full cost recovery based on the $135.00 price. Embargoes are equally unlikely given the current administration's reluctance to support such measures. One possible alternative involves a proposal which would require that US origin uranium be used as feed for any enriched product produced with marginally priced SWU. It is doubtful, however, that the producers would consider this an adequate resolution.

It seems unlikely that the courts will dismiss the complaint out of hand. Extended legal maneuvering and new negotiations between the two sides are likely outcomes of the lawsuit.

© NUEXCO 1985

HISTORICAL MARKET DATA

EXCHANGE AND TRANSACTION VALUES SINCE JANUARY 1980

Determined as of the last day of the month indicated

© NUEXCO 1985

NUEXCO

HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	32.50	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	**15.25**

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	**15.90**

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	**0.80**

© NUEXCO 1985

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry—All Groups[1] (1969=100)	Award Rates of Pay Indexes Australia—Adult Males In Mining Wage and Salary Earners, Weekly Rates[2] (1976=100)
1983 Avg.	401.2	181.8
Aug 1983	403.0	180.7
Sep 1983	402.9	180.6
Oct 1983	397.5	188.3
Nov 1983	395.5	188.3
Dec 1983	399.2	188.1
Jan 1984	399.2	188.6
Feb 1984	402.5	188.5
Mar 1984	403.9	188.3
Apr 1984	404.2	196.2
May 1984	403.8	196.9
Jun 1984	404.9	196.9
Jul 1984	408.5	196.9
Aug 1984	413.3	196.9
Sep 1984	412.1	196.9
Oct 1984	408.7	—

P = Preliminary R = Revised since last month

CANADA

	Industry Selling Price Index: Manufacturing[1] (1971=100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines* (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Metal Industries Non-ferrous[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1983 Avg.	298.8	—	—**	14.30	—	—	11.17
Sep 1983	301.1	17.66	14.90	14.41	11.99	10.32	11.29
Oct 1983	301.6	17.73	15.27	14.65	11.76	10.03	11.30
Nov 1983	301.8	17.82	15.29	14.67	11.78	10.62	11.38
Dec 1983	302.9	17.84	15.11	14.66	11.86	10.60	11.51
Jan 1984	305.4	17.74	15.27	14.74	11.91	10.84	11.69
Feb 1984	306.6	17.78	15.59	14.90	12.04	10.82	11.51
Mar 1984	308.7	18.05	15.52	14.82	12.14	10.84	11.58
Apr 1984	310.5	18.06	15.83	15.10	11.96	10.34	11.63
May 1984	310.6	18.48	15.64	15.06	12.11	10.16	11.65
Jun 1984	311.0	18.08	15.48	14.80	12.38	10.40	11.66
Jul 1984	312.8	17.81	15.72	14.92	12.53	10.18	11.82
Aug 1984	312.7R	17.24	15.36	14.92	12.44	10.34	11.78
Sep 1984	312.0	17.68R	15.96R	15.34R	12.51R	10.52R	11.90R
Oct 1984	312.3R	17.64P	16.05P	15.19P	12.65P	10.64P	12.00P
Nov 1984	313.5	—	—	—	—	—	—

P = Preliminary R = Revised since last month

For annual averages prior to 1983, and for notes pertaining to these statistics, see pages 23-26 of Report 190 of June 1984.

*The 1980 average for Metal Mines was incorrectly reported as 10.59. The correct average is 10.58 (see Report 190).

**Two different methods were used in the 1983 "Metal Mines" category in reporting survey data, and Statistics Canada did not publish a 1983 average. The March 1983 figure for the old method was 14.73 and for the new method was 14.84. The published average for 1983 in Report 190 was a Nuexco calculation based on the available monthly statistics for 1983 with the exception of the March figure, where only the 14.84 value was taken into account.

© NUEXCO 1985

NUEXCO

GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

	Average Declared Working Costs per per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982=100)[2]	Consumer Price Index[3] (1975=100)[4]	Producer Price Index All Groups[5] (1975=100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1983 Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
Oct 1983	—	—	270.0	281.0	693,225	311,418
Nov 1983	—	—	271.4	281.6	688,459	317,485
Dec 1983	53.70	119.6	273.2	283.7	690,750	333,595
Jan 1984	—	—	274.7	283.3	689,807	326,619
Feb 1984	—	—	278.4	286.5	702,553	335,906
Mar 1984	55.30	123.1	281.9	288.0	715,628	342,332
Apr 1984	—	—	286.1	290.2	712,963	327,550
May 1984	—	—	288.3	292.6	710,040	327,937
Jun 1984	56.95	126.2	291.2	295.3	717,009	347,121
Jul 1984	—	—	295.1	296.0	717,121	369,964
Aug 1984	—	—	297.0	300.8	721,905	361,357
Sep 1984	60.64	133.2	299.9	304.1	721,723	359,218
Oct 1984	—	—	303.7	308.7	—	—
Nov 1984	—	—	307.4	—	—	—

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4]			
	Industrial Commodities (1967=100)	All Commodities (1967=100)	(1967=100)	(1972=100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
Aug 1983	317.3	304.7	300.3	—	12.54	13.46	10.62	8.62
Sep 1983	317.1	305.3	301.8	216.44	12.62	13.46	10.70	8.73
Oct 1983	318.5	306.0	302.6	—	12.67	13.55	10.79	8.71
Nov 1983	318.3	305.5	303.1	—	12.64	13.56	10.86	8.77
Dec 1983	318.4	306.1	303.5	218.53	12.75	13.33	10.90	8.84
Jan 1984	319.1	308.0	305.2	—	12.67	13.38	10.91	8.88
Feb 1984	320.6	308.9	306.6	—	12.81	13.34	10.90	8.86
Mar 1984	321.9	311.0	307.3	220.58	12.85	13.33	10.95	8.88
Apr 1984	322.5	311.4	308.8	—	12.91	13.30	10.97	8.89
May 1984	323.3	311.7	309.7	—	12.99	13.37	11.02	8.89
Jun 1984	323.9	311.4	310.7	222.40	12.96	13.40	11.03	8.91
Jul 1984	324.0	312.0	311.7	—	13.02	13.36	11.12	8.95
Aug 1984	323.5	310.9	313.0	—	13.10	13.51	11.13	9.00
Sep 1984	322.3	309.5	314.5	224.36	13.20R	13.39R	11.23R	9.08
Oct 1984	323.2	309.4	315.3	—	13.28P	13.53P	11.31R	9.07P
Nov 1984	323.8	310.4	315.3	—	—	—	11.38P	9.18P

P = Preliminary R = Revised since last month

For annual averages prior to 1983, and for notes pertaining to these statistics, see pages 23-26 of Report 190 of June 1984.

© NUEXCO 1985

INDEX TO 1984 REPORTS
Numbers 185-196

INDEX

Category	Topic	Report Number	Page Number
Analysis & Commentary	Federal Energy Regulation Commission (Part 2)	185	20
	US Nuclear Power Plant Backlog	188	20
	Nuclear Power Plant Licensing in Japan	188	22
	Non-US Nuclear Power Plant Backlog	189	19
	DOE, Enrichment Policy, and National Interest	191	12
	US Government's Uranium Enrichment Program	193	12
	Enriched Uranium Sales: Effect on Supply	193	14
	US and European Uranium Purchases 1979-84	193	21
	Theory and Economics of the Tails Assay	195	16
	DOE Role as Business or Government Service	196	2
	SWU Price Dependence on the Tails Assay	196	14
Australia	1983 Review	187	18
	Government Moderating Uranium Stance	188	17
	ASTEC Advocates Greater Role in Market	190	12
	Labor Party Affirms Uranium Policy	192	14
	Government-Enforced Ban on U Exports to France	194	16
	Government Purchase of QML Uranium	195	20
	Roxby Downs Production Plans	196	25
Basic Considerations	US DOE Gaseous Diffusion Plants	185	21
	Eurodif	188	26
	The De-Enrichment Swap	189	25
	Urenco	191	16
Belgium	1983 Review	187	19
Canada	Drilling Results of Cigar Lake Discovery	185	19
	1983 Review	186	24
	Key Lake Update	190	12
	Ontario Hydro Candu Upgrading Program	190	13
Central Africa	Update on Uranium Projects	191	23
Enrichment	USEC Effect on Secondary SWU Market	185	2
	Terms of Draft USEC	185	3
	Impact of Draft USEC on Uranium Consumption	185	5
	Terms and Conditions of Revised USEC	186	7
	Comparison of USEC and Requirements Contracts	186	8
	USEC Termination Charges	186	9
	1983 Secondary Market Review	187	2
	New US DOE SWU Prices	189	2
	Enrichment Suppliers' Market Shares after USEC	195	2
Essay	Bids, Offers and Inquiries	188	3
	The Changing Role of Brokers	192	12
Finland	1983 Review	187	22
	FOCUS: Nuclear Power Program	190	16
France	1983 Review	187	19
	FOCUS: Nuclear Power Program	187	24
	Uranium Industry Structure	190	19
FR Germany	Isar Unit 2 Construction Halt	186	22
	1983 Review	187	20
Italy	ENEL Plan for Nuclear Power Growth	185	19
	1983 Review	187	20
Japan	FOCUS: Nuclear Power Infrastructure	185	29
	1983 Review	186	26
	Recent Construction Progress	188	17
	Utilities Evaluate Enrichment Options	188	18

© NUEXCO 1985

(continued)

NUEXCO

INDEX

INDEX TO 1984 REPORTS
Numbers 185-196

Category	Topic	Report Number	Page Number
Japan (cont'd)	FOCUS: Uranium Enrichment in Japan	189	29
	Results of Annual Price Negotiations	189	15
	Site Selection for Fuel Cycle Facilities	191	21
	FY83 Generation Results	191	22
	Site for Enrichment and Other Facilities	193	25
	FOCUS: Nuclear Fuel Fabricators	194	14
	MITI Advisory Committee Findings	194	16
	Reactor Status Update	196	25
Korea	Update on 1984 Plant Construction	193	31
Netherlands	Nuclear Power Opinion Poll Results	186	22
	1983 Review	187	21
Portugal	1983 Review	187	21
PR China	Trade Developments with West	190	13
Raw Materials	World Uranium Production in 1983	186	38
	The Rossing Project (Part 1)	188	30
	The Rossing Project (Part 2)	189	31
	The Palabora Project	192	15
	Uranium in the USSR	194	21
	Update on Uranium Resources in South Africa	196	26
South Africa	1983 Review	186	29
	PMC Production Results	188	18
	Plans to Curtail Uranium Production	188	18
	Beisa Mine to be Closed	189	16
	First Quarter Production Results	189	16
	Second Quarter Production Results	192	14
	Release of the NUCOR Resources Report	193	25
	Third Quarter Production Results	195	21
Spain	1983 Review	187	20
	Government Announces Nuclear Cuts	188	19
Sweden	1983 Review	187	21
	FOCUS: Nuclear Power Program	196	20
Switzerland	1983 Review	187	20
	Defeat of Anti-Nuclear Referenda	194	19
Taiwan	Update on Nuclear Power Program	193	31
United Kingdom	FOCUS: Nuclear Power Program	185	25
	1983 Review	187	21
	Commercial AGR Progress	193	27
United States	1983 Review	186	31
	Uranium Producer Activities in 1983	186	35
	1983 Consumption vs. Production	187	22
	UNC—Gulf Settlement	190	15
	1984 Nuclear Power Plant Progress	193	28
	IEC Acquires Westinghouse Lamprecht Property	194	20
	EIA 1983 Production and Resources Statistics	195	22
	Uranerz-UNC Uranium Settlement	196	25
Uranium Pricing	Monthly Pricing	all	1
	1983 Review	186	1
Index to 1983 Reports		185	39

© NUEXCO 1985

NUEXCO

REPRESENTATIVES AND CONSULTANTS

AUSTRALIA

Peter Stork
Oratom Consulting*
5 Gould Ave.
St. Ives
NSW 2075, Australia
Telephone: (61-2) 449-6783
Telex: 23976 (COMTLX)

JAPAN

Kazy Yokota
Japan Tech Services*
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telex: 242-5060 (JATECH J)

SOUTH AFRICA

Chris I. Von Christierson
Southern Prospecting (Pty) Limited*
P.O. Box 61409
Marshalltown 2107
Republic of South Africa
Telephone: (27-11) 838-1868
Telex: 4-89878 SA

TAIWAN

Edward Bee
Bee & Liang Company, Ltd.*
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
TWX: 785-11570 (BEELIANG)

UNITED STATES

Harold C. Lindberg*
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

Ralph O. Smith*
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 272-6246

SPECIAL CONSULTANTS

James C. C. Stewart
U.K. Nuclear Industry

Claus C. Thiesen
Japan Nuclear Industry

W. Bryan Webster
International Business Development

*Independent contractors representing Nuexco